

## **The Basics of Proper Hydration During Prolonged Exercise**

Martin D. Hoffman, MD

Proper hydration during prolonged exercise can help you avoid performance impairment from dehydration and serious, potentially life-threatening complications from overhydration. In this short summary, I will review some basic principles that should help you maintain proper hydration during an ultramarathon.

### **1. Expect some weight loss during exercise**

The oxidation of stored fuel during exercise results in loss of body weight. Furthermore, production of metabolic water during fuel oxidation and the release of water stored with glycogen as muscle and liver glycogen are metabolized will help to maintain the body's total water pool during exercise. That is because this water that is generated and released within the cell will enter the circulation due to osmotic, hydrostatic and oncotic gradients. Therefore, body weight must be lost during prolonged exercise in order to avoid becoming overhydrated. We have calculated that weight loss during a 100-mile mountain ultramarathon should be on the order of ~3-8 pounds (~2-5% of body weight).<sup>7</sup> The appropriate amount of weight loss should be as much as ~2-6 pounds (~1-4% of body weight) for a 50-mile ultramarathon, and as much as ~5-10 pounds (~3-7% of body weight) for a 200-mile ultramarathon! So, don't be concerned about some weight loss within these ranges. On the other hand, if you are not losing weight or you are gaining weight during exercise, then you should reduce your fluid intake in order to reduce your risk of developing exercise-associated hyponatremia (EAH).

### **2. Overhydration is a risk for hyponatremia**

The primary underlying etiological factor for symptomatic EAH is sustained fluid (water or sports drinks) intake in volumes resulting in the accrual of a positive fluid balance.<sup>6</sup> For most athlete-related symptomatic cases of EAH, impaired water clearance due to non-osmotic secretion of arginine vasopressin is an important contributing factor.<sup>6</sup> While EAH is frequently documented in association with hypovolemia,<sup>8,18</sup> symptomatic EAH is virtually exclusively seen in those who gain or lose inadequate weight during exercise as a result of overhydration.<sup>14,18</sup> Thus, there is no debate that overhydration is a risk for the development of symptomatic EAH. Since there has been considerable morbidity from EAH and a number of deaths have resulted from EAH, avoidance of overhydration is paramount to safe exercise.

### **3. Drink to thirst**

Thirst is an evolutionarily developed and precisely regulated mechanism that protects plasma osmolality and circulating blood volume. These mechanisms prompt when drinking is required to prevent excessive dehydration. Though the concept that thirst provides an adequate stimulus to maintain proper hydration during exercise may still be under debate by some and you have

undoubtedly heard that it is inadequate, past recommendations emphasizing that thirst is an inadequate stimulus for maintaining proper hydration were largely intended for situations where dehydration might develop quickly from high sweat rates. There is now ample evidence that drinking to thirst, even during prolonged exercise under hot ambient conditions, will allow maintenance of proper hydration<sup>10,11,20,26</sup> and will attenuate thermal and circulatory strain.<sup>2</sup> Proper fluid intake during exercise need not be complicated – listen to your body and it will tell you when you need to drink. By doing so, you will avoid both dehydration and overhydration.

#### **4. Programmed drinking can be dangerous**

It is not unusual to come across recommendations that endurance athletes should use “programmed” drinking. Typically, this advice is to determine sweat rate by measuring body weight before and after a timed workout, and then drink in competitions at this calculated sweat rate so that the water lost in sweat is fully replaced. First, it should be evident that replacing all water lost in sweat should not be the goal, as this will result in overhydration. But, beyond that, sweat rate also varies considerably across conditions. Consider a situation in which you have presumed you need to match all of your weight loss during exercise with fluid intake, and you have calculated that your rate of sweat loss is 1000 ml per hour. But, the conditions during your race are a bit different than your test conditions and you have overestimated your needs by 25% (250 ml per hour). If you drink that full 1000 ml per hour, then in 4 hours, you have consumed a full liter (~1.4% body weight) more than necessary to keep your weight constant. Then, recognizing that you should have lost ~1-2% of body weight to keep the body water pool stable, you would have actually overhydrated by over 2% of your body weight during this 4-hour time period. Under the right circumstances, that could induce symptomatic EAH, as in a case we observed and have described.<sup>9</sup> It is far better to simply drink to thirst than to try to rely on a programmed drinking approach.

#### **5. Supplemental sodium intake is not generally necessary**

Sodium intake during exercise will drive thirst and may help prevent weight loss, but supplemental sodium has been demonstrated to not be necessary during prolonged exercise even under hot conditions for up to 30 hours.<sup>11,13</sup> The sodium consumed during meals should be adequate to replace losses during routine exercise<sup>4</sup> and the sodium taken in with a typical ultramarathon race diet allows for avoidance of salt-depletion dehydration.<sup>11,13</sup> Furthermore, sodium intake during exercise will not prevent EAH in the presence of overhydration.<sup>14,27</sup> Excessive sodium intake may even increase the likelihood of overconsumption of fluids leading to overhydration and an increased risk of developing EAH.<sup>9,14</sup> This may occur from the combined effects of gastrointestinal and/or hepatic-portal osmoreceptors providing an early stimulus of thirst without elevation in blood osmolality,<sup>16,24,25</sup> fluid retention from non-osmotically stimulated secretion of arginine vasopressin<sup>6</sup> and sodium loss in the urine from secretion of brain natriuretic peptide.<sup>5,14,29</sup>

#### **6. Dehydration is not generally a cause of heat illness**

Dehydration results in a lower sweating rate for a given core temperature.<sup>21</sup> This has raised concern for the potential that heat dissipation through evaporative cooling could be reduced if

fluid replacement during exercise is insufficient. However, it is now recognized that severe heat illness during exercise is most likely to occur during high intensity activities, and can occur without dehydration.<sup>1</sup> Furthermore, there is no reason to believe that excessive fluid ingestion will prevent serious heat illness.<sup>19</sup> Our work has shown that serious elevations in core temperature seem to not be a concern during the relatively low intensity exercise of an ultramarathon, even under hot conditions.<sup>28</sup> Simply drinking water as desired during prolonged exercise will be adequate to prevent serious elevations in core temperature.<sup>2</sup>

### **7. Dehydration or electrolyte loss is not generally a cause of muscle cramping**

Growing evidence from experimental<sup>3,17</sup> and cohort<sup>22,23</sup> studies suggests that muscle cramping related to endurance exercise results from neurological changes rather than uncompensated water and sodium losses incurred during exercise. Our work showing that 100-mile ultramarathon runners with muscle cramping had higher post-race plasma creatine kinase concentrations than those without cramping provides evidence that those developing cramping are placing greater demands on their muscles relative to their current state of training.<sup>12</sup> Our findings of a lack of difference between those with and without cramping in body weight change, post-race plasma sodium concentration, sodium supplement intake and total sodium intake provides further evidence that exercise-associated muscle cramping is not generally related to fluid and sodium imbalances under such conditions.<sup>12,15</sup> At present, the thought is that if you want to avoid muscle cramping, then be appropriately trained and compete within your level of training. If you develop muscle cramping during the event, then stretching the muscle along with a brief rest or reduction in intensity will often control the cramping.

### **8. Limited urination is not necessarily a signal of dehydration**

Urine production should be reduced and concentrated during exercise as a result of shunting of blood away from internal organs towards exercising muscles and to the skin for removal of heat. But, it can be challenging to know the extent to which a reduction in urine production can be of concern. Key in this discussion is the recognition that reduced urine production to some extent is normal. Equally important is a recognition that urine production will also be reduced as EAH is developing because this condition is associated with the non-osmotically stimulated secretion of arginine vasopressin,<sup>6</sup> which serves to reduce urine production. Under such circumstances, a presumption that more fluid intake is necessary will only make the situation worse by increasing the extent of dilutional hyponatremia. Monitoring body weight change can help clarify if one might be dehydrated or overhydrated. But, given that accurate weight scales are typically not available, the amount of fluid consumed relative to the demands should be considered in assessing if one might be overhydrating or dehydrating.

### **9. Carry enough water between water sources to support thirst**

It is important to avoid being without access to fluids during prolonged exercise. Under certain race conditions, this will mean that it is necessary to estimate the volume of fluids that must be carried between the available water sources. Obviously, you want to balance the need for access to water with avoidance of unnecessary weight carriage in the form of water. Determining the amount of water you should carry is best achieved by learning your personal needs so that you

can accurately estimate the volume you might require, keeping in mind that the volume is dependent on exercise intensity and environmental conditions.

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